

***Kangra Coal (Pty) Ltd:
Ballengeich Colliery
Determination of the Assimilative
Capacity of V30 Catchment***
February 2025



M²ENCO



Title:

Determination of the Assimilative Capacity of the V30 Catchment in support of a Water Use License Application for Ballengeich Colliery

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Executive Summary

The Ballengeich Colliery Mine is located on Portion 19 of the farm Ballengeich 3299 HS in the magisterial district of Newcastle located in the KwaZulu-Natal Province. The mine was subject to issued Directives in terms of section 19 of the National Water Act, 1998 (Act 36 of 1998) to address the impacts of Acid Mine Drainage on the Horn River.

The area had been mined by means of underground and opencast mining where all coal reserves had been exploited. Mining was conducted through a board and pillar as well as conventional strip method (roll-over method) followed by concurrent rehabilitation practices. As with any mining development an impact on the water resource is to be expected. Lack of appropriate mitigatory measure implementation has led to moderate to high impacts on the Horn River as well as the Ngagane River further downstream of the mining area.

The ambient surface water quality in the Horn River revealed that the water resource in the area has deteriorated due to acidification stemming from Acid Mine Drainage (AMD). Any uncontained spillage from acidic decant, polluted storm water run-off from the overburden and discard stockpiles and seepage from the pollution Control Dams (PCD's) will contribute towards degradation of water quality in the V31K catchment that is part of the upper Buffalo River Catchment. Acidification of water resources could also contribute towards increased levels of metals leading to toxicity of the Horn River and reducing the habitat for various biota. There is a high risk for a long-term residual impact based on the lithologies associated with the coal seam.

Diffuse sources of pollution stemming from uncontrolled seepage and decants could further degrade the resource to unacceptable levels. To address the post closure impacts on water quality an Acid Mine Drainage (AMD) study and decant management plan, to mitigate for the reduced water quality had been drafted for submission to the Department of Water and Sanitation for approval.

This management plan amongst other aspects addresses the following:

- Strategy to address post closure impacts stemming from AMD;
- Predicted degradation of water resources if the AMD is allowed to discharge in an uncontrolled manner;
- Degradation of water quality in V31F, V31G and V31K catchments;
- Proposal to construct a calcitic lime buffer between the PCD's and the Horn River to intercept seepage to the water resource;
- To convert the decant point into a successive alkaline producing system (SAPS) from where it discharge towards a constructed anaerobic wetland system along the riparian zone of the Horn River;
- Extent of the calcitic lime buffer as well as the size of the anaerobic wetland must be determined by a registered professional engineer as approved by the Regional Head of the Department of Water and Sanitation.

This rehabilitation report has as an objective to address the post closure impacts with associated long-term management measures to be considered as an integral component



of passive waste water treatment technology. The approach is based on the assimilative capacity of the receiving water resources whereby the Waste Load as determined by means of mass balance modelling was used to determine the impact of the treated water on downstream water uses. The study has revealed sufficient assimilative capacity in the Ngagane River system to ensure that the Present Ecological Status (PES) of Class C for the catchment will not be detrimentally impacted. With the implementation of a passive treatment option linked to a Water Use License Authorisation, the long-term impacts from AMD could be effectively mitigated at a cost effective method. All potential concerns as raised by Regulatory Authorities as well as Interested and Affected Parties could be adequately addressed with the concomitant impact mitigation to acceptable levels (low to moderate) by implementing the following treatment options:

- Installation of open limestone trenches;
- Implementation of an anaerobic constructed wetland;
- Construction of an Anoxic Limestone Drain.

All measures as contained in Kangra Coal's Ballengeich Management Plan must be implemented in parallel with the implementation of the passive water treatment system to secure a feasible project.



1 INTRODUCTION

1.1 Purpose of Report

M² Environmental Connections (Pty) Ltd (hereafter referred to as MENCO) was appointed by Kangra Coal (Pty) Ltd (hereafter referred to as Kangra) to conduct a specialist study for the determination of the assimilative capacity of the Horn River situated within the municipal area of Newcastle, KwaZulu-Natal Province (refer **Figure 1-1**). The need for the Assimilative Capacity Study is that the Mining Right holder requires an authorisation to treat an acidic decant water that stems from defunct coal operations at Ballengeich in the Newcastle area. The proposed treatment process entails the implementation of a passive water treatment system that will be based on a waste load allocation and assimilative capacity of the receiving water resource (Ngagane River) to remediate acid mine drainage (AMD) that enters the Horn River.

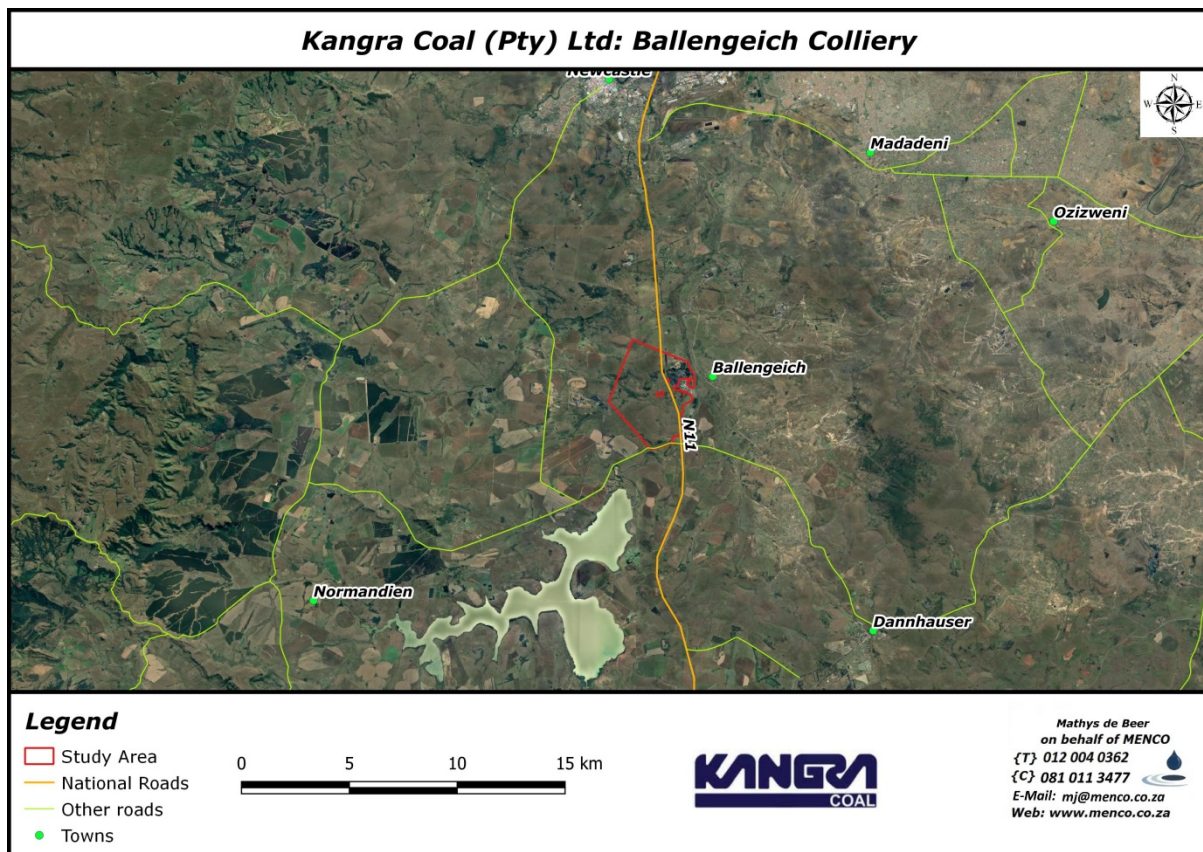


Figure 1-1: Locality Map

The proposed project area is located within the Pongola-Mtamvuna Management Area as illustrated in **Figure 1-2**. The Ngagane and Horn River tributaries of the Thukela Basin are characterised by severe water quality problems stemming from mining and heavy industrial activities within the catchment. In order for a coal mine to apply for a Water Use License Application, several departmental requirements need to be adhered to. Considering the type of water use all waste related water uses are subject to the compilation of an Integrated Water and Waste Management Plan as the technical



supporting document. In the instance of a Section 21(f) and (g) water use application it is required from the applicant to at least provide the following specialist studies:

- Waste Load Allocation of the receiving water resource;
- Assimilative Capacity of the receiving water resource; and
- Environmental Risk Assessment associated with the discharge.

Therefore, the purpose of this study is to fulfil the information requirements from the Department of Water and Sanitation in order to allow for informed decision making.

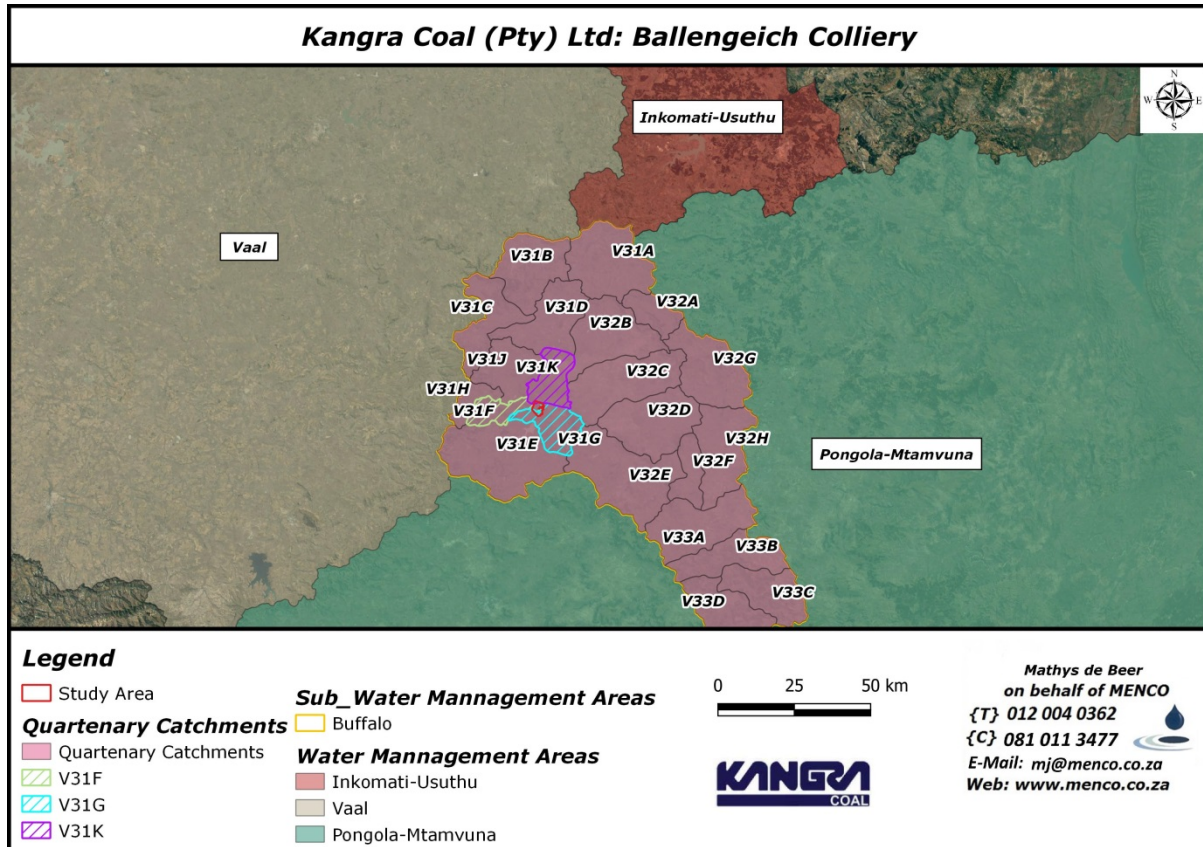


Figure 1-2: Pongola-Mtamtuna Water Management Area

1.2 Description of Receiving Water Body

The Surface Water Study conducted by GCS (2016) for the Horn River revealed that the sub-catchment is regarded as impaired. The Horn River forms part of the V31F quaternary drainage area and its head waters originate on the farm Horn River 4305 near Normandien.

The Ngagane River meanders in an easterly direction from its headwaters (approximately 607 m east of the KwaZulu-Natal-Free State border) in the Low Drakensberg Escarpment through the Ntshingwayo Dam in the Chelmsford Nature Reserve, between the Eskom owned non-operational Kilbarchan Colliery 2 and the Ngagane settlement and around Madadeni to join the Buffalo River.

The Ngagane River constitutes the following quaternary catchment drainage areas:

- V31E – Upper Ngagane to Ntshingwayo Dam
- V31F – Horn to confluence with Ngagane



- V31G – Refer V31K
- V31H – Ncandu to confluence with Ngagane
- V31J - Ncandu to confluence with Ngagane
- V31K – Ngagane from Ntshinwayo Dam to confluence with Buffalo River

The Ballengeich Colliery is situated in close proximity to the Horn River. This property was subject to historic coal mining practices and some of the mining activities were abandoned without proper rehabilitation.

Polluted water emanating from the abandoned coal mines is one of the major causes of water quality problems experienced in this area.

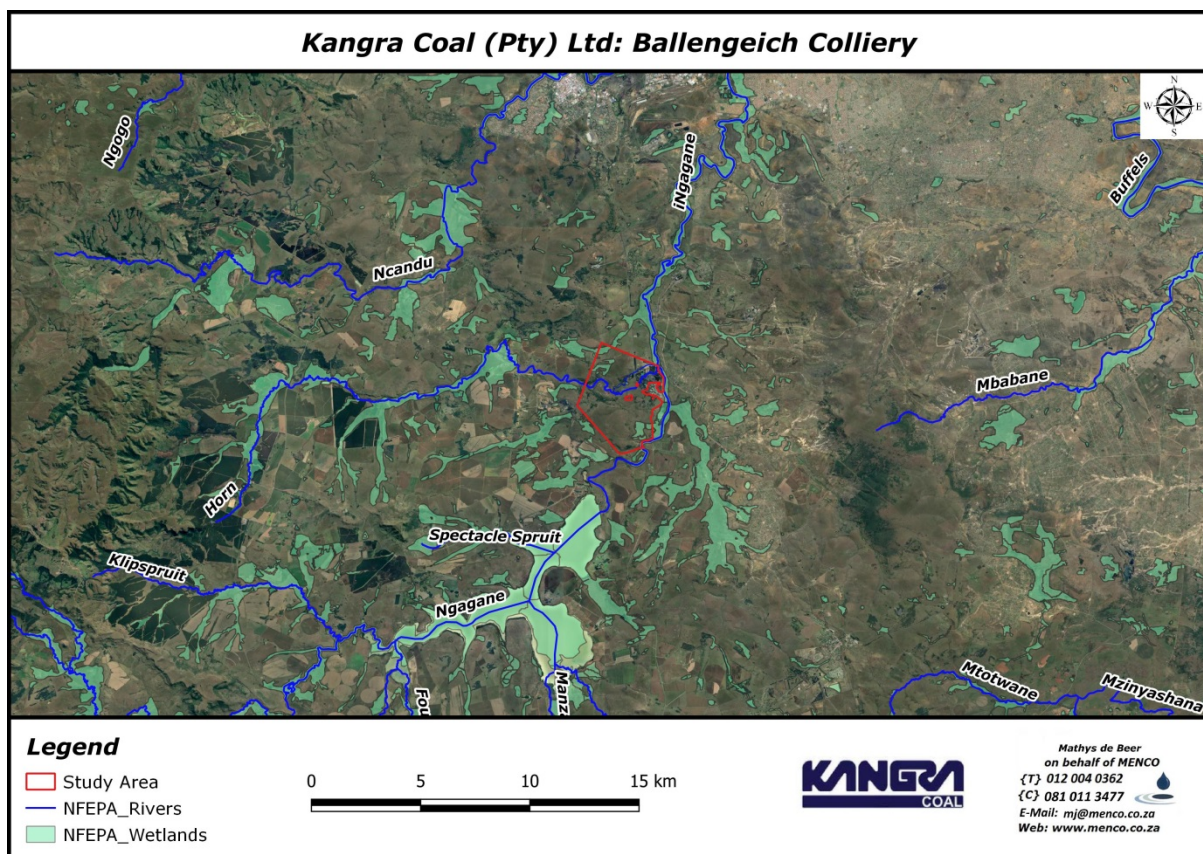


Figure 1-3: Rivers in Vicinity of Project Area

1.3 Project Background

Ballengeich Colliery (Pty) Ltd has an approved Mining Right issued by the Department of Mineral Resources for coal mining activities on portion 19 (Remaining Extent) of the farm Ballengeich 3299 HS. The project area is characterised by several defunct mining activities that ceased during the early 1990's. Based on historic records (Hancox and Gotz, 2014) Ballengeich and Kilbarchan Collieries opened in the late 1890's and was operational until the 1990's. Kangra Coal is the current owner of Ballengeich Colliery. Shanduka Coal Resources owned a 26% shareholding in Kangra Coal and operated under Natal Cambrian Colliery opencast and underground mining activities at the following operations:

- Ballengeich 3299;



- Kilbarchan 2969; and
- Mooikrantz 9562

1.4 Constructed Wetlands for AMD Treatment

Wetlands have several functions that aid in the removal of metals in drainage and ameliorate AMD. These characteristics are required for certain processes to occur: absorption and ion exchange, bioaccumulation, bacterial and abiotic oxidation, sedimentation, neutralization, reduction, and dissolution of carbonate minerals. The contaminants caused by AMD of concern are sulphate, manganese, iron, and heavy metal concentrations.

Processes within natural wetlands have been found to remediate contaminants within AMD. Therefore, imitation of these processes can work similarly in constructed wetlands. Wetlands have organic-rich substrates which exchange dissolved metals. This exchange occurs between the dissolved metals and abundant humic and fulvic acids contained within the substrate (Wildeman et al. 1991). Wetland sediments are generally anaerobic below a thin oxidized surface layer and contain organic carbon for microbial growth (Gambrell & Patrick 1978). The anoxic zone of the sediments provide conditions which favour microbial and chemical reducing processes, transforming iron and sulphates to hydrogen and sulphides (Fennessy & Mitsch 1989). Soluble metals are converted to insoluble forms by the anoxic conditions of wetland sediments (Fennessy & Mitsch 1989). Settling of suspended solids occurs from water velocity control of the wetland vegetation (Brooks 1984). Snyder and Aharrah (1985) verified Typha wetlands as effective removers of iron and manganese.

Kleinmann (1985) recorded data that states iron concentrations dropped from 20-25 mg/L to 1 mg/L, manganese concentrations dropped from 30-40 mg/L to 2 mg/L in a Typha wetland. Sphagnum spp. has also shown significant effect on concentrations of iron, manganese, sulphate, and other mineral concentrations (Kleinmann 1985; Wieder et al. 1985). Plant roots will retain arsenic and other metals (Sobolewski 1997). Plants also generate microenvironments that assist in the reduction and oxidation processes (Wildeman et al. 1991). Certain bacteria, such as those in the genera *Desulfovibrio* and *Delsulfotomaculum*, employ sulphate in anaerobic respiration (Mitsch & Gosselink 1986). These are but a few of the many examples of how a wetland can treat AMD, and therefore by employing knowledge in wetland construction, simulate these biological processes for AMD remediation.

1.5 Wetland Design

The design of a constructed wetland for the treatment of acid mine drainage varies upon site characteristics. The most important design considerations are:

- Biochemical processes,
- Loading rate and retention time,
- Slope,
- Substrate,
- Vegetation,
- Sediment control,
- Hydrogeomorphic,
- Seasonality, and



- Regulatory issues.

Selection criteria need to be applied in order to determine the most appropriate treatment for AMD. In general net alkaline water is needed for an aerobic constructed wetland. In the case of net acid water with low dissolved oxygen (DO) levels, ferric iron and aluminium, an anoxic limestone drain may be selected. Higher concentrations of DO, ferric iron and aluminium are more suited for anaerobic wetlands coupled with a successive alkaline producing system (SAPS) or limestone channels. It is also reported that anaerobic wetlands are in general six times larger and more costly than aerobic systems.

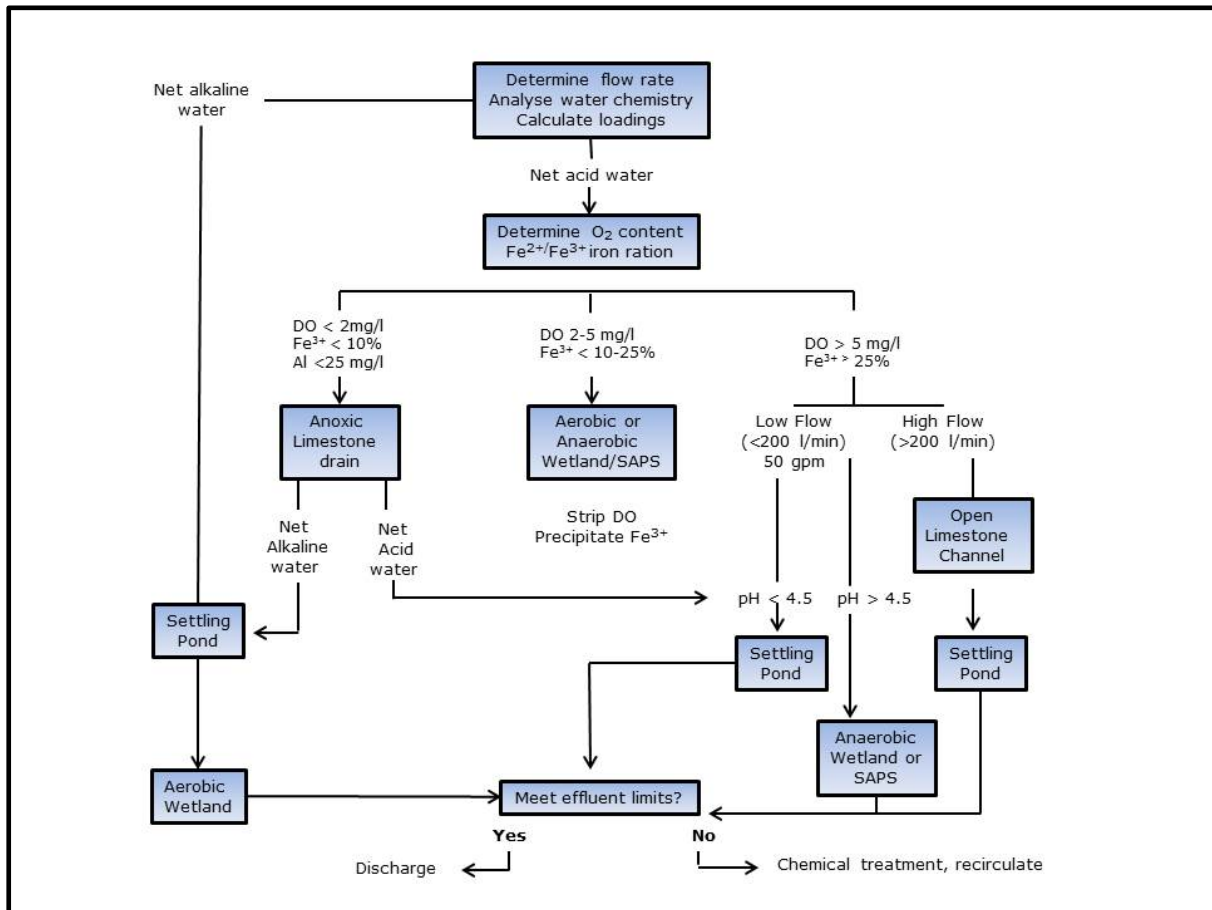


Figure 1-4: Flow diagram for passive AMD treatment selection

Conceptual design parameters for anaerobic wetland systems are based on the following:

- Wetland area is designed using an acidity loading factor of 3.7 – 7 g/m²/d
- Anoxic limestone drain sizing
- Open limestone channels are sized using 0.03 – 0.19 mg/l acidity per meter of channel length with slope of greater than 20% for optimum performance



2 DESCRIPTION OF WATER QUALITY PROBLEM

The water quality problem that is being experienced in the Newcastle/Ballengeich area relates to Acid Mine Drainage (AMD) stemming from old historic, defunct and abandoned mining operations.

2.1 Statutory Requirements

In terms of the Constitution of South Africa, Act 107 of 1996 it is stated in section 24 that:

- Everyone has the right –
 - o To an environment that is not harmful to their health or wellbeing; and
 - o To have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that –
 - o Prevent pollution and ecological degradation;
 - Promote conservation; and
 - Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

South African environmental legislative requirements are depicted in the National Environmental Management Act (NEMA), the National Water Act (NWA) and the Mineral Petroleum Resources Development Act (MPRDA) to give effect to the stipulations as contained in the Constitution.

Environmental Authorisation in terms of NEMA is based on the following Principles:

- Decision processes should be harmonised;
- A precautionary approach needs to be followed;
- The polluter pays principle applies;
- Duty of Care from Cradle to Grave;
- Follow an Integrated and Holistic Approach
- Operate within the Carrying Capacity of the Resource;
- Consideration of all alternative options select the Best Practice Environmental Option (BPEO);
- Strive for continuous improvement;
- Accountability and Liability; and
- Transparency Democracy.

The MPRDA makes provision in terms of sections 37, 38, 39 and 40 that the concepts of Integrated Environmental Management are considered for implementation when dealing with Mining Right applications. It is further required that in terms of section 41 of the MPRDA the Mining Right Holder provides for financial provision for remediation of environmental damage. It is required in terms of section 43 that mines apply for a closure. A closure certificate can only be issued once the mine can provide proof that long-term residual impacts can be effectively mitigated towards steady state conditions.

Furthermore, in terms of section 107(1) of the MPRDA, the Minister may, by notice in the Government Gazette, make regulations regarding:-

- (a) (i) The conservation of the environment at or in the vicinity of any mine or works;



- (ii) The management of the impact of any mining operations on the environment at or in the vicinity of any mine or works;
- (iii) The rehabilitation of disturbances of the surface of land where such disturbances are connected to prospecting or mining operations;
- (iv) The prevention, control and combating of pollution of the air, land, sea or water, including ground water, where such pollution is connected to prospecting or mining operations;
- (v) Precautionary provision by the Holder of any right, permit or permission for the carrying out of an environmental management programme;
- (vi) The establishing of accounts in connection with the carrying out of an environmental management programme and the control of such accounts by the Department;
- (vii) The assumption by the State of responsibility or co-responsibility for obligations originating from regulations made under sub-paragraphs (i), (ii), (iii) and (iv) of this paragraph, and
- (viii) The monitoring and auditing of environmental management programmes

Considering section 107(1)(a)(vii) of the MPRDA the State has to assume responsibility for dealing with the pollution stemming from the defunct and abandoned coal mines in the Witbank area.

Chapter 3 of the NWA deals with the protection of water resources. In terms of water resource protection the following principles applies:

- The water resource is indivisible;
- Minister is the Public Trustee (custodian) of all water resources;
- Act makes provision for both consumptive and non-consumptive use of water;
- Water is required to satisfy basic human needs and protect ecosystems (Reserve);
- Best Practical Environmental Option must be implemented when using water;
- Pollution is defined as being harmful and must be prevented;
- Financial measures must be provided to curb the impacts of pollution;
- Management at catchment level; and
- Allow for public consultation processes

In addition section 19 of the NWA is applied by the regulator to prevent and remediate the effects of pollution and can be directed to the owner of land, a person in control of land or who uses or who occupies the land where pollution occurs or is likely to occur. In terms of section 151 of the NWA a polluter could be directed to comply with Act in terms of section 19, 20, 53 or 118.

2.2 Information on Verified Impairment

The former Department of Water Affairs and Forestry has conducted numerous studies in the Upper Buffalo River catchment to investigate water quality deterioration (DWAF, 2004). This has led to the formulation of an Internal Strategic Perspective (ISP) for the former uThukela Water Management area entailing amongst others a Water Resource Management Plan for the Buffalo River catchment which include the Ngagane River System. The WRMP covers the following key aspects:



- Catchment assessment;
- Development of Water Quality Planning Limits;
- Evaluation of management options;
- Sub-catchment integrated water quality management plans;
- Assessment and development of Water Quality Monitoring Programme;
- Compilation of an overall IWQMP including sub-catchment strategies;
- Implementation program.

The application by Ballengeich Colliery to treat Acid Mine Drainage (AMD) from the defunct mining operation on Portion 19 (Remaining Extent) of the farm Ballengeich 3299 HS needs to consider the sub-catchment strategies in order to determine the feasibility of the project in relation to other water users on a holistic basis.



3 APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Description of Quaternary Drainage Areas

The V31 tertiary catchment consisting of quaternary drainage area V31E - H and V31J – V31K forms the Upper Buffalo river catchment. It has a drainage area of 11,461 km². The gross catchment of the V31 tertiary area (V31E-K) is 3,948 km². The total catchment area of the Buffalo River Basin is approximately 30,000 km² in extent (DWAF, 2004). Major dams in the V31E drainage area is the Ntshingwayo Dam with a storage capacity of 9.2Mm³. The river flow in the V31 drainage area is highly dependent on seasonal rainfall and depends further on base flow during the dry winter months. The mean annual runoff (MAR) for the V20E, V31E and V31F quaternary catchments is 135.87 Mm³/annum.

The DWS operates several monitoring stations within the Ngagane River system. Water Quality monitoring stations applicable to the project would include the following stations:

- V3H27 – WMS V31_102770, Ntshingwayo Dam on Ngagane River;
- V3H18 – WMS V31_102763, Downstream of Ntshingwayo Dam on Ngagane River;
- V3H3 – WMS V31_102751, At Ballengeich on Ngagane River;
- 188867 – WMS V31_188867, Upstream Siltech at Bridge to Ntshingwayo Dam on Ngagane;
- V3H9 – WMS V31_102754, Horn River at Ballengeich; and
- 188868 – WMS V31_188868 Ballengeich upstream Horn at Railway Bridge on Ngagane.

3.2 Classification of Water Body

The latest classification (DWS, 2022) revealed that Resource unit 3.2 – Horn River to confluence with Ngagane River (V31F) is characterised by extensive agricultural practises inclusive of irrigation. The Horn River ranges from a PES: C - E category (moderately to severely impaired) due to impacts from old mines. The Newcastle Water Treatment Plant located downstream of the confluence is in the process to increase abstraction to 220 ML/day (Umgeni, 2020) by implementing an upgraded 30ML/d module for Newcastle.

The following classification is applicable to the Ngagane River (refer Table 3-1:).

Table 3-1: Ngagane River classification

Water Resource	Catchment	PES	EIS	REC	NMAR 10 ⁶ m ³	EWR % MAR	EWR Volume
Ngagane	V31E	B	Moderate	B	110,827	30.38	33.674
Horn	V31F	C	Moderate	C	25,045	20.09	5.031

3.3 Resource Quality Objectives



The latest Ngagane River Resource Quality Objective (RQO) study by the DWS (DWS, 2022) has set the following Resource Quality Objectives to be achieved as illustrated in **Table 3-2** and **Table 3-5**.

Table 3-2: Resource Quality Objectives for Ngagane River to confluence with Buffalo

Variable	Unit	RQO, 2022	Reserve, 2006	GCS, 2014
Electrical Conductivity (EC)	mS/m	-	70 - 150	70
Total Dissolved Solids as TDS	mg/l	≤350	-	-
pH range		6.5 – 9.0	>6.5 - <8.5	6 – 9
Sulphate (SO ₄)	mg/l	-	<360	200
Phosphate (PO ₄)	mg/l	0.05	<0.1	-
Total Inorganic Nitrogen as TIN	mg/l	≤2.0	-	-
Alkalinity as CaCO ₃	mg/l	-	-	-
Fluoride as F	mg/l	-	-	-
Aluminium as Al	mg/l	≤0.105	-	-
Cadmium as Cd	mg/l	≤0.0012	-	-
Iron as Fe	mg/l	≤0.1	-	0.1
Copper as Cu	mg/l	≤0.0073	-	-
Manganese as Mn	mg/l	≤0.15	-	0.05
Lead as Pb	mg/l	≤0.0095	-	-
Cobalt as Co	mg/l	≤0.05	-	-
Zinc as Zn	mg/l	≤0.002	-	-
Sodium as Na	mg/l	-	<167	100
Magnesium as Mg	mg/l	-	<39	30
Calcium as Ca	mg/l	-	<145	32
Chloride as Cl	mg/l	-	<62	100

3.4 Present Ecological Status

The Reserve Study for the Ngagane River (DWAf, 2007) specifies the following Resource Classification as contained in Table 3-3: EWR estimates for V31F WR90 cumulative flows.

Table 3-3: EWR estimates for V31F WR90 cumulative flows

Month	Natural Flows			Modified Flows (EWR)			
				Low Flows		High	Total
	Mean	SD	CV	Maintenance	Drought	Maintenance	Maintenance
Oct	1.277	2.147	1.681	0.110	0.030	0.146	0.256
Nov	2.616	3.375	1.428	0.178	0.020	0.315	0.492
Dec	3.537	4.177	1.181	0.238	0.020	0.462	0.699



Month	Natural Flows			Modified Flows (EWR)			
				Low Flows		High	Total
	Mean	SD	CV	Maintenance	Drought	Maintenance	Maintenance
Jan	4.977	4.342	0.873	0.334	0.141	0.231	0.565
Feb	5.212	4.433	0.850	0.395	0.166	1.076	1.471
Mar	3.756	3.654	0.973	0.377	0.159	0.385	0.763
Apr	1.689	2.292	1.357	0.265	0.113	0.103	0.368
May	0.587	0.888	1.512	0.145	0.060	0.000	0.145
Jun	0.259	0.366	1.412	0.080	0.036	0.000	0.080
Jul	0.250	0.542	2.171	0.063	0.029	0.000	0.063
Aug	0.313	0.918	2.933	0.060	0.028	0.000	0.060
Sep	0.571	1.551	2.715	0.070	0.032	0.000	0.070

The flow requirements for the Ngagane River are contained in Table 3-4:.

Table 3-4: EWR estimates for V31E WR90 cumulative flows

Month	Natural Flows			Modified Flows (EWR)			
				Low Flows		High	Total
	Mean	SD	CV	Maintenance	Drought	Maintenance	Maintenance
Oct	5.015	8.694	1.773	0.831	0.180	0.692	1.523
Nov	10.616	15.283	1.440	1.344	0.120	1.572	2.916
Dec	14.896	17.496	1.175	1.847	0.080	2.436	4.283
Jan	22.009	20.268	0.921	2.663	0.664	1.218	3.881
Feb	24.351	20.537	0.843	3.252	0.804	6.083	9.335
Mar	17.137	16.523	0.964	3.110	0.771	2.189	5.298
Apr	7.723	10.011	1.296	2.243	0.564	0.569	2.812
May	2.864	3.983	1.391	1.287	0.290	0.000	1.287
Jun	1.301	1.489	1.145	0.723	0.200	0.000	0.723
Jul	0.987	1.072	1.086	0.530	0.156	0.000	0.530
Aug	1.478	4.856	3.284	0.510	0.151	0.000	0.510
Sep	2.449	7.554	3.085	0.576	0.167	0.000	0.576



Table 3-5: RQO's for IUA 2: Ngagane River

Component	Sub-component	RQO	Indicator	Numerical Limit			Context of RQO and numerical limit
Quantity	Low Flows	EWR maintenance low and drought flows: Ngagane River at the EWR site May13_EWR3 (-27.819, 29.987) in V31K NMAR = 160.12 x10 ⁶ m3 TEC=C/D category The maintenance low flows and drought flows must be attained to support the upstream and downstream aquatic ecosystem of the Ngagane River to the confluence with the Buffalo River.	Maintenance and drought flows required for the Ngagane River	Month	Maintenance Low flows (m ³ /s)	Drought Low flows (m ³ /s)	May13_EWR3 for TEC=C/D (Baseflows, freshets/floods)
				Oct	0.366	0.091	
				Nov	0.560	0.068	
				Dec	0.762	0.051	
				Jan	1.138	0.527	
				Feb	1.541	0.711	
				Mar	1.269	0.587	
				Apr	0.928	0.433	
				May	0.539	0.202	
				Jun	0.326	0.112	
				Jul	0.243	0.123	
				Aug	0.234	0.119	
				Sep	0.273	0.111	
	Freshets	EWR freshets to be released from Ntshingwayo Dam (V3R001) and Horn River	Freshets required for the Ngagane River	Month	Freshet (m ³ /s)	Days	
				Nov	10.0	2	
				Dec	12.0	2	
				Jan	15.0	2	
				Feb	20.0	2	
				Mar	10.0	2	
Quality	Nutrients	Nutrient levels must be improved to sustain the aquatic ecosystem health and to meet the prescribed ecological state (C ecological category)	Ortho-phosphate (PO ₄ -) as Phosphorus	≤0.05 mg/L (50th percentile)			
			Total Inorganic Nitrogen (TIN-) as Nitrogen	≤ 2.0 mg/L (50th percentile)			
	Salts	Salinity concentrations must be maintained or improved to support downstream users	Total Dissolved Solids	≤350 mg/L (95th percentile)			C Category – Slight improvement of Present state



Component	Sub-component	RQO	Indicator	Numerical Limit	Context of RQO and numerical limit
	System Variable	pH range must be maintained within limits specified to support the aquatic ecosystem and water user requirements.	pH range	6.5 (5th percentile) and 9.0 (95th percentile)	Aquatic ecosystem as the driver
	Toxics	The concentrations of toxins should not be toxic to aquatic organisms and a threat to human health.	Ammonia as N	≤ 0.0725 milligrams/litre (mg/l) (95th percentile)	Strictest of ecological specifications.
			Aluminium (Al)	≤ 0.105 milligrams/litre (mg/l) (95th percentile)	Ecological Reserve manual (2008), South African Water Quality Guidelines (1996)
			Cadmium (Cd) soft	≤ 0.0012 milligrams/litre (mg/l) (95th percentile)	
			Manganese (Mn)	≤ 0.15 milligrams/litre (mg/l) (95th percentile)	
			Iron (Fe)	≤ 0.1 milligrams/litre (mg/l) (95th percentile)	Manganese and Iron – Domestic user water quality guideline (SAWQGs, 1996).
			Lead (Pb) hard	≤ 0.0095 milligrams/litre (mg/l) (95th percentile)	
			Copper (Cu) hard	≤ 0.0073 milligrams/litre (mg/l) (95th percentile)	
			Nickel (Ni)	≤ 0.07 milligrams/litre (mg/l) (95th percentile)	Cobalt – Irrigation user water quality guideline (SAWQGs, 1996)
			Cobalt (Co)	≤ 0.05 milligrams/litre (mg/l) (95th percentile)	
			Zinc (Zn)	≤ 0.002 milligrams/litre (mg/l) (95th percentile)	Zinc - Aquatic Ecosystem water quality guideline (SAWQGs, 1996).
			Atrazine	≤ 0.078 milligrams/litre (mg/l)	Ecological specification. Ecological Reserve manual (2008). No monitoring data.
			Mancozeb	≤ 0.009 milligrams/litre (mg/l)	Human health is the driver. Australian



Component	Sub-component	RQO	Indicator	Numerical Limit	Context of RQO and numerical limit
					Drinking Water Guideline
			Glyphosate	≤0.7 milligrams/litre (mg/l)	Human health is the driver. USEPA drinking water guideline
			Oil and grease	2.5 mg/l	General and special standards for effluent in terms of NWA, 1956. No monitoring data
		Hydrocarbons	Benzene	≤0.01 milligrams/litre (mg/l) (95th percentile)	WHO drinking water guideline. Human health limit. No available monitoring data.
			Toluene	≤0.7 milligrams/litre (mg/l) (95th percentile)	WHO drinking water guideline. Human health limit. No available monitoring data
	Habitat	Instream Natural flow pattern must be maintained in C Ecological Category. Alien invasive controls must be implemented, maintained and/ improved.	IHI and IHAS	Instream Habitat Integrity (class C) Ecological Category (60 – 79%) Riparian Integrity - Class ≥B Ecological Category (80 – 90%) IHAS to be	Keep it at a C to maintain a C/D
		Riparian Habitat Natural flow pattern must be maintained in C Ecological Category. Alien invasive controls must be implemented, maintained and/ improved.	VEGRAI	VEGRAI survey every 5 years. VEGRAI ≥C Ecological Category (>60%)	
	Fish	Flow and water quality sensitive Fish species to be	FRAI	During survey in all flow habitat classes all species present.	



Component	Sub-component	RQO	Indicator	Numerical Limit	Context of RQO and numerical limit
		maintained or improved to a PES C/D ecological category.	<i>Amphilius natalensis</i> (ANAT) <i>Barbus (Enteromius) paludinosus</i> (BPAU) <i>Labeobarbus natalensis</i> (BNAT) <i>Barbus (Enteromius) pallidus</i> (BPAL) <i>Barbus (Enteromius) anoplus</i> (BANO)	BNAT, BPAL and BANO – 2 of 3 spp present as habitat indicators; and ANAT ≥ 3 individuals per species FRAI EC: C/D (60 - 79%)	
	Aquatic invertebrates	Flow and water quality sensitive macro-invertebrate assemblages to be maintained. Macro-invertebrate assemblages must be maintained within a C/D ecological category or improved upon.	SASS 5 MIRAI Baetidae >2 spp Heptageniidae Leptophlebiidae Tricorythidae Leptoceridae Hydropsychidae >1spp Elmidae Economidae	3 biotopes sampled; assemblages to be ≥ B abundances; SASS 5 scores: ≥213 ASPT score: ≥7.2 MIRAI EC: C/D (50 – 79%)	
	Diatoms	Ecological water quality should be maintained as moderate quality	Specific Pollution Sensitivity Index (SPI) Percentage pollution tolerant values (%PTV)	SPI: 12 - 14 PTV: 20 to <40%	



4 ASSESSMENT OF SOURCES

The main purpose of this assimilative assessment study is to understand the significance of potential discharge impacts on waste load allocations in order to develop strategies to ensure that impacts can be minimised or mitigated to an acceptable level. The identification of potential issues is broad and covers the construction as well as the operational phase of the proposed AMD Rehabilitation project.

Issues or impacts of low significance will not be carried through to the Impact Assessment, with supporting reasons, to ensure that the Impact Assessment phase focuses on the potentially “significant impacts” identified for the proposed project. Section 6 of the Report identifies the full range of potential impacts. Some significant impacts were identified that should be investigated in detail in the Impact Assessment Phase. These environmental impacts need to be simulated, predicted and assessed using numerical models to assist in the quantification of the impact and to recommend appropriate mitigatory measures.

4.1 Overview of Modelling Process

Water quality modelling entails a process that involves the prediction of water pollution using mathematical simulation techniques. A typical water quality model consists of a collection of formulations representing physical mechanisms that determine position and momentum of pollutants in a water body.

4.2 Point Sources

A major component for determining the current status of water resources within the sub-catchment related to the proposed project is the identification of point sources within the footprint of the mining area. According to the Thukela River ISP (DWAf, 2004) the water quality in this sub-area is under threat from the coal mines. Some 62 million m³/annum is predicted to decant from workings post closure. The management of these decant volumes is being addressed by the mining industry with a number of projects addressing treatment and irrigation management options. Therefore, it is critical for the Ballengeich Colliery project to identify and quantify the point sources on Portion 19 (Remaining Extent) of the farm Ballengeich 3299 HS that contributes towards the AMD decant. The following point sources form part of the waste load to the V31G and V31K catchments:

- Industrial activities from the Newcastle area;
- Waste discharges from various point sources (such as WWTP);
- Impacts associated with mining with high salinity and low pH's as a result from acid mine drainage stemming from numerous coal mining activities.

In accordance with the Thukela Water Management Area: Interim Strategic Perspective (DWAf, 2004) the following Management Actions of the Department will form part of the approach to reduce the impact from point sources as contained in **Table 4-1**.



Table 4-1: Water Resource Management Perspectives Relevant for the Buffalo tertiary Catchment

Water Quality Management Objective	Impacts	Management Actions
Ensure a sound and reasonable balance between development impacts and the protection of the resource, both surface and groundwater and ensure that the water in the system remains fit for use.	• Groundwater pollution • High COD and suspended solids • Releases from Ntshingwayo Dam to dilute pollution • mining and industrial activities in the upper Buffalo catchment have resulted in degradation of the water resource from a quality perspective • Closed mine decants in the Sundays and Buffalo catchments	The water quality situation in the WMA should be continuously monitored and necessary measures implemented to reduce negative impacts. Causes of problems should be understood for the effective design of solutions. The closed mine rehabilitation programme should continue and required resources made available to ensure that potential water quality problems are contained. Role players in the Sundays and Buffalo River catchments should be engaged to develop a management plan to deal with the mine pollution problems, particularly at closure and during rehabilitation.

Direct discharges to rivers could therefore be managed through a licensing process on the basis of assimilative capacities of those impacted rivers and on Receiving Water Quality Objectives. Where these limits exceeded (often through the cumulative impact of diffuse discharges), water becomes unavailable to some or unfit for use by down-stream water users. The pre-cautionary principle needs to be considered when dealing with discharges from point sources.

4.3 Non-point Sources

Diffuse or non-point sources may be less visible than direct discharges but are no less pernicious. If not quantified accurately diffuse discharges only compound the problem by reducing the assimilative capacity until water becomes unfit for use, expensive to treat and a danger to human health. The acidic decant along the dam wall of the PCD complex at Ballengeich Colliery is regarded as a major diffuse contributor of pollution.



4.4 Estimating Pollution Source Loadings

The estimation pollution source loadings are based on set End-of-Pipe Discharge Standards. These standards represent a target concentration at the point of wastewater discharge to ensure that the quality of the wastewaters as it enters the receiving water resource still adheres to the Receiving Water Quality Objectives. The standard method of converting the RWQOs into end-of-pipe discharge standards is described below.

The method has also been digitised as part of the RWQO Model. 3.3 - *How Does One Convert RWQOs to End-of-Pipe Discharge Standards?* The basic formula for determining the End-of-pipe discharge standards (Recommended or Maximum Allowable Resource Directed Value) is:

$$C_W = \frac{C_R(M_R + 1)}{M_R} - C_S$$

Where:

M_R = Mixing ratio is rate of discharge (Q_W) divided by rate of stream flow (Q_S);

C_S = Receiving stream concentration (C_R) is determined using the reference condition for the receiving water body. This should be determined from long-term records and calculated as the median value for low flow periods (winter in the summer rainfall areas and summer in the winter rainfall area)

C_R = Desired maximum in-stream concentration (C_R) is determined using the reference condition plus the maximum allowable variation for the chosen class, as given in the latest RDM documentation to determine C_R

4.5 Assimilative Capacity Calculation

The assimilative capacity specifically for heavy metals can be calculated by using the equation as stated below:

$$A_{cap} = (C_{max} - C_{back}) * NDWF * 86.4 \text{ kg/day}$$

Where:

- C_{max} = maximum permissible concentration RQO 95% percentile value in mg/l;
- C_{back} = background upstream concentration in mg/l – mean value;
- NDWF = Normal Dry Weather Flow in the river in m³/a;
- $\frac{(60*60*24)}{1000} = 86.4$



5 DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determining the Load Capacity

The term “assimilative capacity” refers to the capacity of a water resource to assimilate disposed waste, through processes such as dilution, dispersion, and chemical and biological degradation, without water quality changing to the extent that fitness for use or ecosystem health is impaired. Assimilative capacity depends on many factors and it is evident that quantifying assimilative capacity to the extent that this can translate into useful management instruments could be extremely complicated. It is therefore the Department’s policy to use this as a routine management instrument only in the particular context of dilution capacity.

5.2 Meteorological Data

Reference is made to the Hydrological Assessment Study (GCS, 2016) that provides detail on the meteorological data considered applicable to the project site. As stated in section 3 of the Hydrological Study rainfall data was obtained from Ballengeich weather station 0370834_W.

5.3 Hydrological Calibration

The hydrological calibration for the model was based on available options to select a “target flow” for the receiving water body. The most likely option was to select the maintenance flow that was determined as part of the Reserve study conducted for the Ngagane River catchment. The maintenance low flow is generally regarded as the flow that would occur for about 70% of the time. Taking into account the variables that may influence the critical conditions of the Reserve (typically the 7Q₁₀ flow which is the lowest 7-day duration mean flow with a 10 year recurrence interval), the hydrological calibration was based on the wet months stemming from October to March. In addition, as specified in Table 5-1:, it is evident that the mine doesn’t need to discharge during the dry months due to the high rate of inflow throughout the year.

Table 5-1: Groundwater flow data for mining area (GCS, 2014)

Area (m ²)	Mining Seam	Maximum Drawdown (m)	Cone of depression from edge of pit (m)	Estimated Inflow for the Total Area (m ³ /day)	Estimated Inflow per Boxcut (m ³ /day)	Evaporation for the Total Area (m ³ /day)	Evaporation per Boxcut (m ³ /day)
1273744	No1 and No2	18	Maximum 400 m	400	200	5800	290

It was assumed that discharge may be needed during the wet months and that discharge will be at a rate of 4.629 l/s.

5.4 Water Quality Calibration

Water quality data obtained from the WMS database of the Directorate: Resource Quality Studies had been used in model calibration. The water quality (refer **Table 5-2**) had been used as input data into the Waste Load models



Table 5-2: Measured water quality in study area December 2023

Variable	Decant	PCD	Horn US	Horn DS1
pH – value @ 25°C	5.9	2,6	7,6	7,1
Electrical Conductivity as EC in mS/m	691	500	80,6	87,7
Total Dissolved Solids as TDS in mg/l	7260	3350	540	588
Total Alkalinity as CaCO ₃ in mg/l	152	<5	56	56
Chloride as Cl in mg/l	143	29	7	9
Sulphate as SO ₄ in mg/l	3902	3036	300	334
Sodium as Na in mg/l	841	261	21	29
Potassium as K in mg/l	29	8,6	2,5	2,9
Calcium as Ca in mg/l	435	414	61	66
Magnesium as Mg in mg/l	411	281	51	57
Aluminium as Al in mg/l	0.1	151	<0,1	<0,1
Iron as Fe in mg/l	189	57	<0,025	<0,025
Ferrous Iron as Fe ²⁺ in mg/l	139	0,462	<0,025	<0,025
Ferric Iron as Fe ³⁺ in mg/l	50	56	<0,025	<0,025
Manganese as Mn in mg/l	3.99	16	0,735	0,882

The *in situ* water quality data as captured (refer **Table 5-3**) during the fieldwork conducted during December 2023 had been used in order to characterise the AMD for treatment selection.

Table 5-3: In situ water quality data for Horn and Ngagane River

Variable	Decant	Horn (US)	Horn DS1	Horn DS2
pH	5.9	7.4	7.0	6.8
Dissolved Oxygen (mg/l)	>5.0	9.02	8.91	8.43
EC in mS/m	691	27.1	36.9	39.9
Aluminium as Al in mg/l	<0.100	0.127	0.142	<0.100
Iron as Fe ²⁺	139	0.054	<0.025	<0.025
Iron as Fe ³⁺	50	0.860	2.00	3.30



6 DETERMINATION OF WASTE LOAD

6.1 Waste Load Allocation

The need for determining the Waste Load for the catchment is founded on the following principles of the Waste Discharge Charge System:

- If RQO's are met the management of waste related discharges should be based on achieving discharge standards at minimum cost to the individual dischargers;
- If RQO's are not met or threatened the management of waste discharges should be based on achieving RQO, while minimising the total cost at catchment level (i.e. cost of treatment at source).

Studies have already revealed that there is a high salinity load entering the Upper Buffalo River catchment. Should it be considered feasible by the regulatory authority that Ballengeich Colliery (Pty) Ltd be allowed to discharge AMD into the V31J and/or V31K quaternary drainage areas the following conditions are enforced:

- Discharge will be based on a monitored load;
- Emphasis to be placed on load reduction (taking loads out of the system/disposal of removed loads);
- Control extremely high (or toxic) concentrations;
- Mitigation through removal of waste load from the resource

The WLA for the two scenarios had been calculated using the Resource Water Quality Objectives Model as prescribed by the DWS (DWAF, 2007).

A formula is used to calculate the concentration of a parameter in the receiving water downstream of the discharge. This downstream concentration may then be compared directly with the water quality standard (RQO) to determine whether the discharge will cause an exceedance of the RQO value.

$$T = \frac{FC + fc}{F + f}$$

Where:

- F is the river flow upstream of the discharge;
- C is the concentration of pollutant in the river upstream of the discharge;
- f is the flow of the discharge in m³/s;
- c is the maximum concentration of the pollutant in the discharge in mg/l;
- T is the concentration of the pollutant downstream of the discharge in mg/l

The output of the WLA determination is contained in **Table 6-1** and **Table 6-2** included below. The water quality results as depicted in **Table 5-2** were used in the modelling.



Table 6-1: Waste load for Ngagane River

Parameter	Unit	TWQO	Load from Ballengeich	Flow Ngagane River	Current Concentration mg/l	Load in Ngagane	Load Horn River	Confluence Concentration Ngagane River	Increase (mg/l)	Increase (%)
Waste water quantity	m ³ /d	22742	0.26							
Peak Flow	m ³ /hr	948								
Water Temperature	° C	>15								
pH		6 – 9			7.2					
Total Dissolved Solids	mg/l	298	78.44	0.776	252	195.55	273.99	353.08	101.08	28.63%
Total Alkalinity	mg/l	40	10.53	0.776	44	34.14	44.67	57.57	13.57	23.57%
Chloride	mg/l	8	2.11	0.776	7	5.43	7.54	9.71	2.71	27.94%
Sulphate	mg/l	127	33.43	0.776	94	72.94	106.37	137.08	43.08	31.43%
Sodium	mg/l	15	3.95	0.776	12	9.31	13.26	17.09	5.09	29.78%
Potassium	mg/l	2.1	0.55	0.776	2	1.55	2.10	2.71	0.71	26.26%
Calcium	mg/l	33	8.69	0.776	27	20.95	29.64	38.19	11.19	29.31%
Magnesium	mg/l	19	5.00	0.776	17	13.19	18.19	23.44	6.44	27.49%
Aluminium	mg/l	0.436	0.11	0.776	0.33	0.26	0.37	0.48	0.15	30.95%
Iron	mg/l	4.61	1.21	0.776	1.98	1.54	2.75	3.54	1.56	44.13%
Manganese	mg/l	1.14	0.30	0.776	0.406	0.32	0.62	0.79	0.39	48.78%



Table 6-2: Waste Load to the Horn River

Parameter	Unit	TWQO	Load from Ballengeich	Flow Horn River	Current Concentrations	Load in Horn River	Load Horn + Ballengeich	New Concentration Horn River (mg/l)	Increase (mg/l)	Increase (%)
Waste water quantity	m ³ /day	928.50	0.01							
Peak Flow	m ³ /hr	38.69								
Water Temperature	° C	>15								
pH		6 – 9			7.2					
Total Dissolved Solids	mg/l	268	70.54	0.273	288	78.62	149.17	546.40	258.40	47.29%
Total Alkalinity	mg/l	40	10.53	0.273	36	9.83	20.36	74.57	38.57	51.72%
Chloride	mg/l	7	1.84	0.273	7	1.91	3.75	13.75	6.75	49.09%
Sulphate	mg/l	111	29.22	0.273	132	36.04	65.25	239.02	107.02	44.78%
Sodium	mg/l	14	3.69	0.273	15	4.10	7.78	28.50	13.50	47.37%
Potassium	mg/l	1.6	0.42	0.273	1.6	0.44	0.86	3.14	1.54	49.09%
Calcium	mg/l	26	6.84	0.273	27	7.37	14.21	52.07	25.07	48.15%
Magnesium	mg/l	19	5.00	0.273	21	5.73	10.73	39.32	18.32	46.59%
Aluminium	mg/l	0.142	0.04	0.273	0.1	0.03	0.06	0.24	0.14	57.79%
Iron	mg/l	2	0.53	0.273	3.3	0.90	1.43	5.23	1.93	36.88%
Manganese	mg/l	0.324	0.09	0.273	0.44	0.12	0.21	0.75	0.31	41.52%



Table 6-3: Mass Balance calculations for Ngagane and Horn Rivers

Variable	[F] (u/s)	[C] (u/s)	Flow - discharge (f)	Max c	FC	fc	F+f	$T = \frac{FC+fc}{F+f}$	Month	Flow [F]
Ngagane River										
Total Dissolved Solids	0.776	298	0.273	450	231.248	122.85	1.049	337.56	Oct	1.277
Total Alkalinity	0.776	40	0.273	44	31.04	12.012	1.049	41.04	Nov	2.616
Chloride	0.776	8	0.273	10	6.208	2.73	1.049	8.52	Dec	3.537
Sulphate	0.776	127	0.273	205	98.552	55.965	1.049	147.30	Jan	4.977
Sodium	0.776	15	0.273	35	11.64	9.555	1.049	20.20	Feb	5.212
Potassium	0.776	2.1	0.273	3	1.6296	0.819	1.049	2.33	Mar	3.756
Calcium	0.776	33	0.273	36	25.608	9.828	1.049	33.78	Apr	1.689
Magnesium	0.776	19	0.273	28	14.744	7.644	1.049	21.34	May	0.587
Aluminium	0.776	0.436	0.273	0.15	0.33834	0.04095	1.049	0.36	Jun	0.259
Iron	0.776	4.61	0.273	7.5	3.57736	2.0475	1.049	5.36	Jul	0.25
Manganese	0.776	1.14	0.273	0.3	0.88464	0.0819	1.049	0.92	Aug	0.313
									Mm ³ /a	24.473
									m ³ /s	0.776
Horn River										
Total Dissolved Solids	0.263	204	0.010	7260	53.652	68.97	0.273	449.99	Oct	0.411
Total Alkalinity	0.263	40	0.010	152	10.52	1.444	0.273	43.90	Nov	0.468
Chloride	0.263	5	0.010	143	1.315	1.3585	0.273	9.81	Dec	0.541
Sulphate	0.263	71	0.010	3902	18.673	37.069	0.273	204.56	Jan	1.749
Sodium	0.263	6	0.010	841	1.578	7.9895	0.273	35.11	Feb	1.297
Potassium	0.263	1.3	0.010	29	0.3419	0.2755	0.273	2.27	Mar	1.363
Calcium	0.263	21	0.010	435	5.523	4.1325	0.273	35.43	Apr	0.871
Magnesium	0.263	14	0.010	411	3.682	3.9045	0.273	27.84	May	0.426
Aluminium	0.263	0.127	0.010	0.1	0.0334	0.00095	0.273	0.13	Jun	0.329
Iron	0.263	0.914	0.010	189	0.24038	1.7955	0.273	7.47	Jul	0.267
Manganese	0.263	0.086	0.010	4	0.02262	0.038	0.273	0.22	Aug	0.253
									Sep	0.326
									(Mm ³ /a)	8.301
									m ³ /s	0.263



Table 6-4: Calculated Assimilative Capacity in the Horn and Ngagane Rivers

Variable	Max RQO Concentration (mg/l)	Background Concentration (mg/l)	NDWF (m ³ /s)	Conversion (kg/day)	Assimilative Capacity Tons/day)	Month	NDWF
Total Dissolved Solids	1000.00	204.00	0.26	86.40	18.09	Oct	0.411
Chloride	100.00	5.00	0.26	86.40	2.16	Nov	0.468
Sulphate	400.00	71.00	0.26	86.40	7.48	Dec	0.541
Sodium	100.00	6.00	0.26	86.40	2.14	Jan	1.749
Potassium	100.00	1.30	0.26	86.40	2.24	Feb	1.297
Calcium	32.00	21.00	0.26	86.40	0.25	Mar	1.363
Magnesium	70.00	14.00	0.26	86.40	1.27	Apr	0.871
Aluminium	0.50	0.13	0.26	86.40	0.01	May	0.426
Iron	1.50	0.91	0.26	86.40	0.01	Jun	0.329
Manganese	4.00	0.09	0.26	86.40	0.09	Jul	0.267
						Aug	0.253
						Sep	0.326
						(Mm ³ /a)	8.301
						m ³ /s	0.263
Variable	Max RQO Concentration (mg/l)	Background Concentration (mg/l)	NDWF (m ³ /s)	Conversion (kg/day)	Assimilative Capacity (Ton/day)	Available (Ton/d)	
Total Dissolved Solids	1000.00	7260.00	0.01	86.40	-5.14	23.23	
Chloride	100.00	143.00	0.01	86.40	-0.04	2.19	
Sulphate	400.00	3902.00	0.01	86.40	-2.87	10.35	
Sodium	100.00	841.00	0.01	86.40	-0.61	2.74	
Potassium	100.00	29.00	0.01	86.40	0.06	2.18	
Calcium	32.00	435.00	0.01	86.40	-0.33	0.58	
Magnesium	70.00	411.00	0.01	86.40	-0.28	1.55	
Aluminium	0.50	0.10	0.01	86.40	0.00	0.01	
Iron	1.50	189.00	0.01	86.40	-0.15	0.17	
Manganese	4.00	3.99	0.01	86.40	0.00	0.09	



6.2 Results

With reference to **Table 6-1** and **Table 6-2** it is evident that the decant entering the Horn River has a detrimental impact in terms of water quality deterioration when compared to the upstream water quality in the catchment. It is also evident from the results contained in **Table 6-4** that there is significant assimilative capacity in the Ngagane River. This is mainly due to the freshets released from the Ntshingwayo Dam situated upstream of Ballengeich to allow a better quality water for abstraction by the Newcastle Water Treatment Plant for further purification to meet the potable water use supply of the Region.

The current situation at Ballengeich Colliery is that acidic decant (AMD) is allowed to enter the Horn River uncontrolled from where it is further diluted at the confluence with the Ngagane River. If the modelled results as contained in **Table 6-5** and **Table 6-6** are compared to a RQO Class III category as per GN 1873 of March 2022 it is found that the heavy metals (Fe, Al and Mn) exceeds the set RQO's. Total Dissolved Solids (TDS) and sulphate (SO₄) have the potential to exceed the more stringent RQO as contained in GN 1873 (refer **Table 3-5**).

Table 6-5: Assimilated capacity for Ngagane River

Variable	Unit (mg/l)	Predicted USEPA Model	Predicted RWQ Model	RQO	RQO Class III
Total Dissolved Solids	mg/l	337.56	353.08	≤350	≤1200
Total Alkalinity	mg/l	41.04	57.57		
Chloride	mg/l	8.52	9.71	≤120	≤300
Sulphate	mg/l	147.30	137.08	≤165	≤500
Sodium	mg/l	20.20	17.09		≤200
Potassium	mg/l	2.33	2.71		
Calcium	mg/l	33.78	38.19		≤150
Magnesium	mg/l	21.34	23.44		≤70
Aluminium	mg/l	0.36	0.48	≤0.105	
Iron	mg/l	5.36	3.54	≤0.1	
Manganese	mg/l	0.92	0.79	≤0.15	

Table 6-6: Assimilated capacity for Horn River inclusive of decant

Variable	Unit (mg/l)	Predicted USEPA Model	Predicted RWQO Model	RQO	RQO Class III
Total Dissolved Solids	mg/l	449.99	546.40	≤350	≤1200
Total Alkalinity	mg/l	43.90	74.57		
Chloride	mg/l	9.81	13.75	≤120	≤300
Sulphate	mg/l	204.56	239.02	≤165	≤500
Sodium	mg/l	35.11	28.50		≤200
Potassium	mg/l	2.27	3.14		
Calcium	mg/l	35.43	52.07		≤150



Variable	Unit (mg/l)	Predicted USEPA Model	Predicted RWQO Model	RQO	RQO Class III
Magnesium	mg/l	27.84	39.32		≤70
Aluminium	mg/l	0.13	0.24	≤0.105	
Iron	mg/l	7.47	5.23	≤0.1	
Manganese	mg/l	0.22	0.75	≤0.15	

6.3 Evaluation of Impacts and Effects

The impact assessment methodology used for the Project is based on an Impact Assessment Rating Matrix as proposed in the formal DEAT Protocol for Environmental Impact Assessment (DEAT, 2002).

The dewatering of the abandoned mine relates to acidic water being neutralised and after stabilisation in an aerobic constructed wetland allowed for discharging to the Horn River catchment. Impacts identified for this project were evaluated against the Department's action plan to protect the upper reaches of the Buffalo River from further degradation from Class C to Class C/D or lower. Dewatering of the mine with concomitant release to the environment will impact on the following components of the Horn River system:

- Altering the seasonal flow fluctuation
- Impact of biodiversity and aquatic ecology
- Impact of water quality

Impact on seasonal flow

Nature: Alteration of the flow regime of the catchment resulting in increased of catchment yield of poor quality, degradation of in-stream riparian habitat and associated decrease in water quality. Increased flow will cause stream bed erosion, bank destabilisation and destruction of biotopes that relates to seasonal fluctuation of base-flow		
	Without mitigation	With mitigation
Extent	Regional (3)	Regional (3)
Duration	Long term (4)	Long term (4)
Magnitude	Very High (10)	Moderate (6)
Probability	Definite (5)	Likely (3)
Significance	85 (High)	39 (Moderate)
Status (positive or negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources	No	No
Can impacts be mitigated?	Yes	Yes
Mitigation: Minimize or control release of treated waste water by means of an anaerobic wetland and SAPS to fall within the specifications of Maintenance Class to protect the watercourses and riparian zones; Minimize disturbance to flow regime and prevent erosion		
Cumulative Impacts: A percentage of the natural sub-catchment of the Horn River will be altered		



Residual Impacts: Yes, neutralised AMD will form FeOH_3 complexes (yellow boy) that act as a slow release system of toxic metals in the event that the pH does not remains within alkaline conditions.

The impact of discharge of treated AMD to the Horn River will have a moderate significance on the catchment, will be definite and rated a long-term negative impact. Mitigatory measures could include AMD neutralisation by means of appropriate technology such as passive treatment or more technically advanced reverse osmosis. On site neutralisation is seen as a cost effective solution and as a result, the significance remain moderate, likely to occur and be a lasting long-term moderate negative impact.

Impact on Biodiversity and Aquatic Ecology

Nature: Neutralised AMD will comply with the pH range of 5.5 – 9.5 and reduced levels of heavy metals but with high levels of salinity. The increased salinity levels will cause the TDS concentration to exceed the RQO of 560 mg/l. In addition the sludge that is associated with AMD will contain high levels of metals that will eventually dissolve and settle within the sediments of the water resource. The sediments accumulate the metals and if toxic levels are reached the aquatic ecology will degrade to SASS5 score of below 70 and ASPT of <3.0. This implies that only resistant macro-invertebrates will survive with no sensitive species, including fish species. The acidic water has the potential to cause riparian vegetation to die-off rendering the habitats unsuited for sustaining a high level of biodiversity		
	Without mitigation	With mitigation
Extent	Regional (3)	Regional (3)
Duration	Long term (4)	Long term (4)
Magnitude	Very High (10)	High (8)
Probability	Definite (5)	Likely (3)
Significance	85 (High)	45 (Moderate)
Status (positive or negative)	Negative	Positive
Reversibility	Low	Medium
Irreplaceable loss of resources	Yes	No
Can impacts be mitigated?	Yes	Yes
Mitigation: Mitigation as proposed incorporates passive waste water treatment systems as the only viable measure that adheres to BATNEEC considering the scale of operation Mitigation that is considered appropriate such as SAPS and ALD needs to be initiated on a site specific scale and needs to cover all seepage areas Appropriate sludge management must be implement where the sludge material is contained in lined impoundments Mitigation must be enforced with the required environmental authorisations and should include but not be limit to permits/licenses, rehabilitation plan and adequate financial provisioning		
Cumulative Impacts: A significant percentage of the natural sub-catchment of the Horn River will be altered and degraded to below the set RQO's		
Residual Impacts: Yes, neutralised AMD will form $\text{Fe}(\text{OH})_3$ complexes (yellow boy) that act as a slow release system of toxic metals.		

It is evident that the uncontrolled release of AMD into the Horn River does not benefit the Horn River catchment downstream of the discharge point. It is acknowledged that the sub-catchment (V31K) is already impacted and is currently rated as a Class C river system (moderately impaired). The Horn River upstream of the decant point has a PES Class B rating and the AMD decant has caused the river to degrade to a Class C/D. By allowing



the continuous discharge of AMD the recommended environmental class (REC) will be maintained but without mitigatory measures in place it will contribute towards further degradation to Class D (critically impaired). No river system should be allowed to degrade below a Class E and every attempt must be made to improve the Horn River catchment to the REC of Class C.

In order to reach this objective the applicant needs the support of the relevant Government Departments to enter into a Public Private Partnership in which the parties take co-ownership of environmental liabilities, responsibilities and rehabilitation requirements. The rehabilitation approach will therefore be aligned with the DMR's Regional Strategy or Master Planning for Rehabilitation of State's liabilities towards defunct and abandoned coal mines.

Impact on Water Quality

Nature: The neutralised AMD will comply with the pH range of 5.5 – 9.5 but will exceed the following set RQO's: Sulphate concentrations will be >500 mg/l, TDS levels >1000 mg/l; EC concentration will exceed the 120 mS/m as set for the sub-catchment. Increased acidity will contribute towards lower alkalinity (<60mg/l CaCO ₃) which in turn will result in low buffer capacity. The AMD will mobilise metals in suspension and increases these metals (Al, Fe, Mn) to have concentrations rated as at toxic levels for all water use sectors. The water quality will be rendered unfit for human consumption and will also have adverse impacts on the aquatic ecology.		
	Without mitigation	With mitigation
Extent	Regional (3)	Regional (3)
Duration	Long term (4)	Long term (4)
Magnitude	Very High (10)	High (8)
Probability	Definite (5)	Likely (3)
Significance	85 (High)	45 (Moderate)
Status (positive or negative)	Negative	Negative
Reversibility	Low	Medium
Irreplaceable loss of resources	Yes	No
Can impacts be mitigated?	Yes	Yes
Mitigation: The applicant must apply for the required water use license authorisation to implement a long-term passive water treatment system such as constructed wetlands; A comprehensive monitoring plan must be developed. The monitoring plan must cater for selected Key Performance Indicators (chemical variables such as SO ₄ , TDS, pH, Ec, Alkalinity), biological monitoring (SASS5, IHAS, VEGRAI, FRAI), sedimentology and participating in toxicological assessment such as DEEEP Mitigation must be enforced with the required environmental authorisations and should include but not be limit to permits/licenses, rehabilitation plan and adequate financial provisioning		
Cumulative Impacts: A significant percentage of the natural sub-catchment of the Horn River will be altered and degraded to below the set RQO's. The increased salt load stemming from the discharge will negatively impact on the Upper Buffalo River catchment. Degraded water qualities could impact on irrigation water use resulting in loss of crop yield. The natural environment will be impacted negatively in terms of increased lost in biodiversity.		
Residual Impacts: Yes, neutralised AMD will form FeOH ₃ complexes (yellow boy) that act as a slow release system of toxic metals.		



The impact of the release of AMD on the water quality will be masked by the fact that the system is already impaired. The waste load and RQO's at Horn River will exceed the allowable limit for downstream water users. The impact is long-term, highly probable and rated as highly significant. Remediation will be required but for a junior mining company not feasible to carry the burden for rectifying the impacts of pollution stemming from historic activities.



7 IMPLEMENTATION PLAN AND PROGRAM

7.1 Selection of Passive Treatment Options

With reference to **Figure 1-4** the characterisation of the AMD at Ballengeich Colliery has revealed the following information as illustrated in **Table 7-1**. The most appropriate passive treatment system for Ballengeich Colliery seems to be an anaerobic constructed wetland unit linked to a Successive Alkaline Producing System (SAPS).

Table 7-1: Results of AMD Characterisation

Criteria	Outcome	Selected Treatment Option
Water Chemistry	Net acidic	Anaerobic wetland / SAPS
Dissolved Oxygen	>5 mg/l	
Iron as Fe ²⁺ /Fe ³⁺ ratio	>25% (calculated at 35%)	
Aluminium as Al <25mg/l	<0.01 mg/l	
Flow in l/min	Low Flow - 4.629 l/s	
pH	Acidic - 5.9 (>4.5)	

7.2 Basin Management Action Plan

The Basin Action Management Plan for the former Thukela WMA was compiled as part of the Interim Strategic Perspective (ISP) report (DWAf, 2004). Please refer to **Table 7-2** for the actions to be considered as part of the rehabilitation approach.

Table 7-2: Action Plan to maintain River Class C at IUA 2, Ngagane River

Objective	Actions
Overall maintenance of Class C	- Improve PES with respect to nutrients and TDS - Ensure that biodiversity within Ntshingwayo Dam Nature Reserve is catered for - To ensure that habitat requirements for riparian biotopes are catered for
Hydrology	Maintain perennial flow and the most important components that make up natural seasonal fluctuation/variation in flow
Geomorphology	- Improve the overall macro-channel structure by ensuring a balance between sediment deposition and sediment conveyance - Exotic vegetation not to be allowed to encroach into the active channel - Ensure that sand and fine gravel are transported through the system - Maintain a shear stress sufficient to maintain sediment transport through the system - Ensure that large floods (>350 m³/s) occur from time to time (forms part of the releases from Ntshingwayo Dam)



Objective	Actions
Resource Quality Objectives	• Maintain existing vegetation composition in riparian zones by maintaining the natural variability in flow fluctuations • To stimulate recruitment and maintain a range of size classes of dominant riparian species in perennial channels (<i>Salix mucronata</i>) • To stimulate recruitment and maintain a range of size classes dominant riparian species in seasonal channels (<i>Rhus gerrardii</i>) • To discourage encroachment of additional exotic species and terrestrial species in riparian zone by periodic flooding
Fish	• To improve the diversity of fish species found at IFR1 (8+species) i.e. create flow conditions that will encourage fish species that were previously recorded from this area to return; • To maintain high diversity of fish biotopes, including areas where water is slow and shallow, fast and shallow, slow and deep and fast and deep • To maintain riffle areas to sustain flow-dependent species such as <i>Amphilius natalensis</i> (ANAT) <i>Barbus</i> (<i>Enteromius</i>) <i>paludinosus</i> (BPAU), <i>Labeobarbus natalensis</i> (BNAT), <i>Barbus</i> (<i>Enteromius</i>) <i>pallidus</i> (BPAL), <i>Barbus</i> (<i>Enteromius</i>) <i>anoplus</i> • To maintain egg laying sites with clean gravel sand bars • Maintain nursery areas with marginal vegetation in shallow bars • Maintain depth in pools for at three larger species • Maintain a range of size classes of fish • Maintain rooted banks for species which require all above specified biotopes
Aquatic Invertebrates	• Maintain high biodiversity of biotopes • Maintain riffles for flow sensitive <i>Baetidae</i> >2 spp, <i>Heptageniidae</i>, <i>Leptophlebiidae</i>, <i>Tricorythidae</i>, <i>Leptoceridae</i>, <i>Hydropsychidae</i> >1spp, <i>Elmidae</i> <i>Economidae</i> species) • Maintain SASS5 scores within the range: Score >100, ASPT >5.5 • Ensure that pH does not drop below 5.5 (presence of <i>Crustacea</i> indicates acceptable pH conditions) • Provide suitable ovi-position sites • To periodically flush benthic diatoms and associated organic flocculant, particularly at the beginning of spring
Water Quality	• To ensure that concentrations of TDS do not exceed the RQO (530 mg/l) • Ensure that nutrient levels are controlled • To ensure no in-stream toxicity



7.3 Other Legislative Tools

There are several legislative tools that need to be considered as part of determining project feasibility. The applicant needs to comply with the conditions as contained in the issued Mining Right in terms of the MPRDA, an Environmental Authorisation in terms of NEMA, a Waste Permit for operating the settling ponds in terms of NEM:WA as well as the consideration of the NEM:BA in relation to the C-Plan of Kwa-Zulu Natal Province.

As specified earlier in the study the proposed mining activity triggers several Section 21 water uses as contemplated in the NWA. Most noteworthy is the Section 21(f) water use for the discharge of water containing waste into a water resource. Authorisation for this water use will be dealt with in conjunction with Section 21(g) water uses that necessitates the development of an Integrated Water and Waste Management Plan.

In addition the requirements as contemplated in GN 267 of March 2017 must be taken into consideration. In this instance it will be a prerequisite that the following specialist studies must be undertaken:

- Geohydrological study;
- Wetland study;
- Civil Engineering Design Report (to cater for the design of the passive treatment option);
- Work Method Statement;
- Updated Integrated Water and Wastewater Management Plan; and
- Public Participation

The Water Use License Application process will commence immediately after the DWS has given their consent that a passive water treatment process is feasible to handle the AMD discharge to the Horn River.

7.4 Successive Alkaline Producing System (SAPS)

In order to achieve the desired health class as stipulated in **Table 3-1**, it would be advised that a passive treatment system is implemented at Ballengeich Colliery. This is done to ensure that water discharged would no longer be labelled as AMD and this system will also have the ability to be decommissioned without any significant impacts on the resource. These systems could also be classed as Acceptable for the protection of the environment without incurring excessive costs on the mine. These systems are further designed to have a low risk of failure. The system proposed for this mine is the Successive Alkaline Producing System or SAPS that is linked to an anaerobic constructed wetland. It was selected as it has the most virtues for this sort of operation and will be fairly affordable to maintain. It is further found that this system has the potential to be 97% effective in the removal of metals and neutralisation of AMD water.

Please refer to **Figure 7-2** for a schematic illustration of the SAPS.

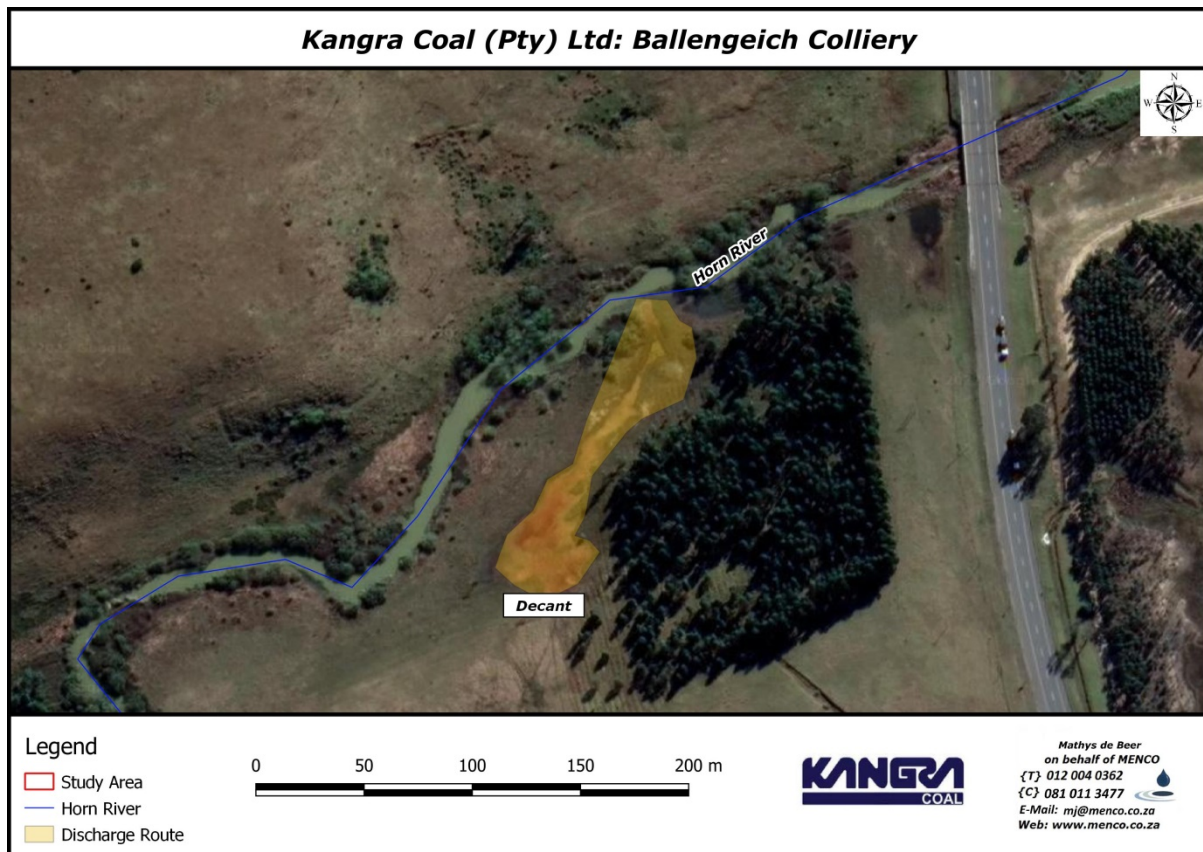


Figure 7-1: Proposed Discharge Route

For this project, it is advised that the system be installed along the riparian zone of the Horn River as indicated in **Figure 7-1**. This plan comprises the collection of the AMD from where the overflow will feed into a compost/organic material area/anaerobic constructed wetland where further passive treatment will take place. Finally, the water will be discharge into the Horn River.

For the AMD discharge and treatment system to be constructed, the design as proposed in **Figure 7-2** is recommended (refer Ford, 2003). It should be noted that this is only conceptual and can be changed when designed by an ECSA Accredited Civil Engineer.

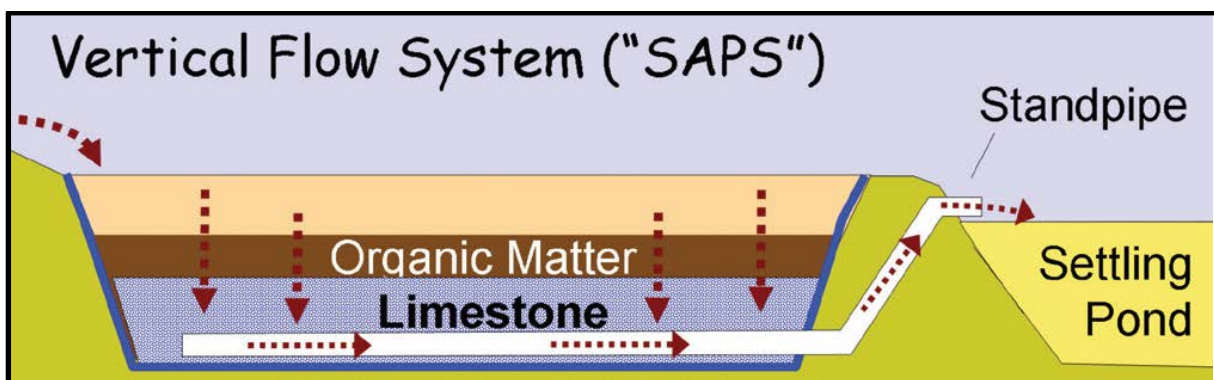


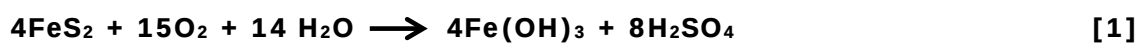
Figure 7-2: Proposed SAPS System



Figure 7-3: Current View of Discharge

7.5 Anaerobic Wetland

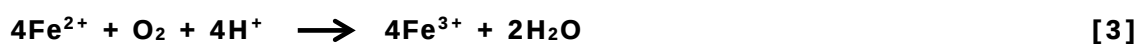
Anaerobic wetlands are used to neutralize acidity and reduce metals to the sulphide form. This reaction consumes H^+ and therefore acidity. The following equations are relevant:



Reaction 1 is the first reaction in the weathering of pyrite and includes the oxidation of pyrite by oxygen. In this reaction sulphur is oxidised to sulphate and Fe^{2+} is released (refer equation 2).



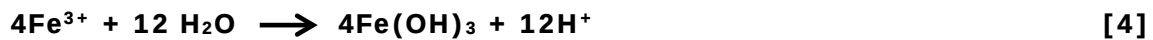
The third reaction involves the conversion of ferrous iron to ferric iron and thereby consumes one mole of acidity. Certain bacteria increase the rate of oxidation from ferrous to ferric iron. This reaction is pH dependent and is slower under acidic conditions (pH 2-3).



The formation of ferric hydroxide precipitate is pH dependent where solids form if the pH is $> pH\ 3.5$. Metals such as Al, Mn and trace elements such as arsenic, cadmium, copper, lead and zinc will also co-precipitate with the iron.



The fourth reaction is the oxidation of additional pyrite by ferric iron. The ferric iron generated in reactions 1 and 2 is a cyclic and self-propagating part of the overall reaction and takes place very rapidly and continues until either ferric iron or pyrite is depleted.



Anaerobic wetlands (refer **Figure 7-4**) may be lined or unlined shallow ponds filled with organic matter, such as compost, and underlain by limestone gravel. Water percolates through the compost and becomes anaerobic where equation 2 is reversed and metals precipitate as sulfides. Microorganisms facilitate this reaction by first consuming oxygen. Alkalinity and H_2S are produced. If the system is improperly sized, if flow dries up, or if extended low temperatures are encountered, the microorganisms will die and the performance will be decreased. Some anaerobic wetlands discharge a sulfide “sewage” effluent, particularly during the first few years.

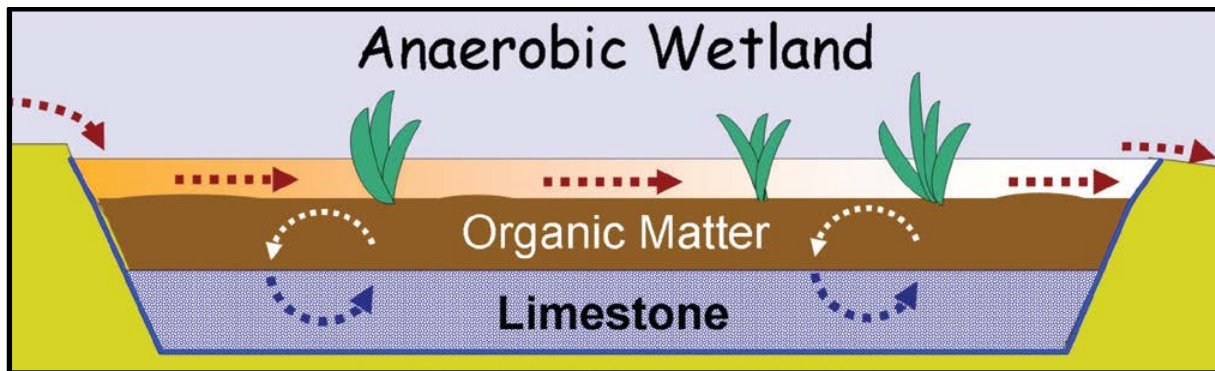


Figure 7-4: Anaerobic constructed wetland

Constructed wetlands are man-made ecosystems that mimic natural conditions. They generally consist of shallow excavations filled with a flooded gravel, soil, organic matter and wetland plants such as *Typha*, *Juncus* and *Scirpus* species.

All the trees felled during the land clearance phase could be chipped and placed within this shallow earth dam as part of the organic matter. The idea is to construct a “wetland” with organic material that will act as a bio-filter for the environment. The construction could be done in a similar way as depicted in the figure above.

7.6 Limestone Rock Drain

A limestone drain (refer **Figure 7-5**) is considered an appropriate system to be installed below the PCD's to intercept seepage as it is a way of ensuring that the pH is stabilised before the water is entering into a system where it might have an impact on downstream water users. The limestone rock drain could be constructed to mimic the natural characteristics of the surrounding watercourses that will also aid in the establishment of diverse biodiversity communities.

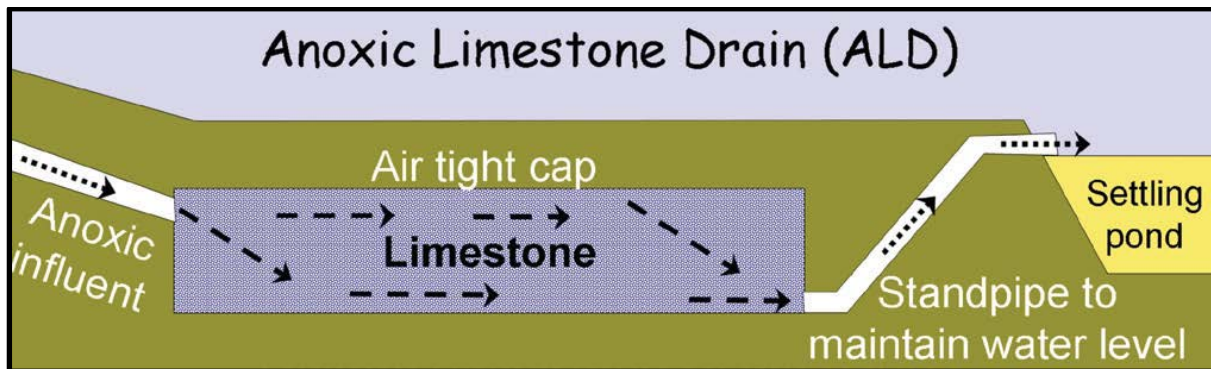


Figure 7-5: Limestone Rock Drain

Constructed wetlands could be successfully applied as a mechanism for metal retention based on the following reactions:

- Formation and precipitation of metal hydroxides;
- Formation of metal sulphides;
- Organic complexation reactions;
- Exchange with other cations and negatively charged elements;
- Direct uptake by living plants

Considering the above, the major interactions of anaerobic wetlands within the substrate provides for a platform whereby significant improvement in the characterisation of the AMD could be achieved.



8 CONCLUSIONS AND RECOMMENDATIONS

The proposed mining rehabilitation activity, inclusive of the construction of a passive wetland system, is situated on a watershed between quaternary drainage areas V311J and V31K. There is a high probability that water related impacts from the passive constructed wetland system could impact on both systems being the Horn River (V31K) and the Ngagane River (V31J). In addition historic water quality data has revealed that the V31K quaternary drainage area is severely impacted by acid mine drainage leaching from the abandoned coal mines as well as seepage from defunct discard facilities.

In order to minimise the impacts on the receiving water resources in the area, two scenarios had been modelled being:

- Discharge of AMD into the Horn River system and determination of the impact at the confluence with the Ngagane River;
- Discharge of treated AMD into the SAPS drainage channel and anaerobic constructed wetland towards the Horn River utilising the assimilative capacity of the Ngagane River as the determining factor to predict impacts.

From the above-mentioned scenarios the following conclusions could be drawn:

- There is adequate assimilative capacity in the Horn – Ngagane River system as the current water quality in the Ngagane River is within the Class III Resource Quality Objectives set for the catchment;
- Key Performance Indicators for mining related impacts such as TDS, SO₄, Alkalinity, Chloride and sodium all marginally exceed the set Target Water Quality Ranges for the Horn River catchment below the discharge point;
- Acidic water releases from the AMD decant point as well as seepage from the PCD's into the Horn River system decreases the buffer capacity to lower levels and degrades the overall water quality of the receiving environment;
- Similarly, discharge towards the Ngagane River also revealed that there is sufficient assimilative capacity in the system. This is due to releases from the Ntshinwayo Dam;
- The current situation at Ballengeich Colliery is that RQO's are exceeded for several variables (SO₄, TDS, Alkalinity, Cl, Na) and that the concentration of selected variables resulted in a significant increase of >40% when compared to the upstream values;
- The impact on water quality will increase the cost for the Newcastle Water Treatment Plant when water abstracted from the Ngagane River is treated for potable supply;
- The Ngagane River is earmarked as the receptor for a waste discharge, but the impact is rated as moderate subject to the condition that the AMD to be discharged is treated;
- In order to allow for a discharge the AMD needs to be neutralised by applying passive waste water treatment technology;
- Active treatment options are not considered as it is seen as too expensive for the scale of mining envisaged for the Ballengeich Colliery Operation;
- The discharge of the neutralised AMD will be subject to a Water Use License Authorisation for the following section 21 water uses:
 - o Section 21(c,i)
 - o Section 21(f)



- o Section 21(g)
- o Section 21(j)

Considering the flow rates, pH levels, and metal ion concentrations of acid mine drainage (AMD) water presented to a given treatment process, achieving the desired acidity and metal ion reductions required can be challenging. Traditional alkalinity-producing systems like horizontal-flow anoxic limestone drains (ALDs) are constructed similar to French drains. They are less effective at handling high acid concentrations and the typically high aluminium and ferric iron levels within AMD water. ALDs are designed to add alkalinity but not to remove metal ions, so outflow clogging is common. In the case of Ballengeich Colliery it was noted that the AMD is characterised by low levels of aluminium and pH values of >4.5. ALD's are considered suitable for the conditions as experienced at Ballengeich Colliery.

Compost wetlands are effective but require large land areas and high retention times to achieve the desired results. The successive alkalinity-producing system (SAPS) combines these two techniques and allows for greater acidity reduction with more reasonable processing times and physical area allowances. The final sizing of the anaerobic wetland will form part of the Civil Engineering Design Report.

Successive Alkalinity Producing System has demonstrated effectiveness in removing high concentrations of metals from AMD. SAPS supplies alkalinity to a mine's acidic waste stream along with aeration to precipitate metals such as aluminium and iron as oxides and hydroxides (oxyhydroxides). The technology is waste stream specific requiring characterising of all organic and inorganic constituents. Based on the severity of AMD in the catchment it is recommended that an iron settling pond for pre-treatment be incorporated as part of the SAPS. The pre-treatment pond provided for a means to aerate the AMD allowing oxidation and precipitation of ferric iron prior to SAPS treatment.

The SAPS consisted of three sections layered as ponded water, compost and crushed limestone. AMD effluent enters the pond just above the compost layer and flows down through the compost and crushed limestone. Discharge from the SAPS enters a settling pond located 0.5 meter below the pond surface from where it is re-routed to a limestone rock drain channel for final treatment before discharge. Based on operations and maintenance the SAPS have demonstrated metal removal efficiency of up to 97 per cent.

The successful implementation of the project will be subject to public participation as well as buy-in from the regulatory authorities.



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